MEIER

Effect of Fineness of Cement upon Tensile Strength and Activity

Civil Engineering
B. S.

1901

$\frac{2}{130}$ 1910

EFFECT OF FINENESS OF CEMENT

UPON TENSILE STRENGTH AND ACTIVITY

BY

WILLIAM MEIER

THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE

IN CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1901

UNIVERSITY OF ILLINOIS

May 29, 1901. 190

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

William Meier

ENTITLED Effect of Fineness on Cement

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Civil Engineering.

Ira O Baker

HEAD OF DEPARTMENT OF Civil Engineering.

Effect of Fineness Upon Tensile Strength and Activity of Cement.

It is well known that the finer a cement is ground the greater covering power it has; and that hence the stronger is a mixture of cement and sand for a given weight of cement. However, there is very little data on the relation between fineness and tensile strength. The writer was able to find only one set of experiments on this subject - that by Mr. B. D. Butler in the Proceedings of the Institute of Civil Engineers, Vol. cxxxii, pages 343-54.

The experiments made by Mr. Butler were undertaken to investigate the generally-accepted theory of the inertness of the coarse particles of Portland cement. In these experiments briquettes were made of neat mortar of three degrees of coarsness. "To ensure that the cohesive strength developed was actually due to the cementitious value of

the coarser particles themselves, and not to the fine cement dust adhering to them each lot was thoroughly washed by shaking it briskly with water in a stopped bottle, decanting the turbid fluid, adding fresh water and repeating the operation until the water was no longer turbid. The washed substance was then immediately filled into an ordinary briquette mould, lightly shaken to eliminate the air bubbles, and then placed under water. The briquettes thus formed were tested for tensile strength at the end of 6 and 12 months respectively." Eight different brands of cement were thus tested.

Mr. Butler's conclusions are summarized as follows:

"1. The coarser particles of cement are not inert but have a certain value, approximately in inverse ratio to their diameters.

"2. The extreme fine grinding of cement decreases its cohesive power, but immensely increases its adhesive power.

"3. The finer grinding of cement immensely

quickens its setting properties.

"4. The finer grinding largely corrects a tendency to unsoundness.

"5 Increase in temperature during setting is governed by the setting properties of the sample, the quicker the setting the greater the rise in temperature."

It will be noticed that Mr. Butler made no sand briquettes with his coarse cement, and that all his tests with the coarse cement were for 6 months and 1 year. Therefore the writer decided to test the tensile strength of sand and cement at earlier ages. Apparently Mr. Butler made no definate quantitative tests of the effect of fineness on activity. Therefore the writer determined to make some fairly complete experiments along this line.

Mr. Butler was certainly correct in beleiving that to determine the effect of fineness on both the tensile strength and activity it was absolutely necessary to eliminate any fine dust which might adhere to the coarse particles. However the writer believes that Mr. Butler's

method of removing the fine dust was objectionable since the water used would act upon the cement and dissolve out part of the cementitious elements. At first the writer attempted to remove the fine dust by washing the cement with gasoline on a sieve; but this was abandoned because of the possible unknown effect of gasoline and because of the slowness and inefficiency of the process. Later a method was adopted of using an air blast in connection with the sieve, which proved very effective and with the coarse grains was very speedy.

The apparatus, Fig. 1, consisted of a sieve with a cover through which the air-blast was admitted by a brass tube. To secure a tight joint a rubber gasget was placed between the sieve and the cover and the two were clamped together by thumb screws. The brass tube in the

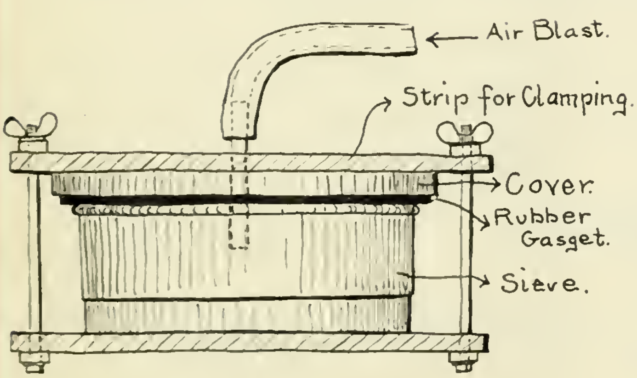

Fig. 1.

cover was connected to the reservoir of compressed air by a rubber tube. The compressed air had a pressure of about 20 pounds per square inch. When the blast was applied a great disturbance was created in the sieve and clouds of dust were driven out. Cement which had been washed with gasoline on a sieve was found to contain considerable dust.

The writer experimented with Alpha (American) and Alsen (German) Portland cement. The fineness of the two cements are shown in the following table.

Ref. No.	Sieves	ALPHA.	ALSEN.
1	Retained on No. 50.	1.0%	0.3%
2	Passed No. 50 retained on No. 74.	5.4	8.0
3	" " 74 " " " 100	3.7	5.6
4	" " 100 " " " 200	18.2	20.0
5	" " 200	71.5	65.7
	Total	99.8%	99.6%

Experiments were made with the following grades of fineness:

1. Passed No. 20 and retained on No. 50.

2. Passed No. 50 and retained on No. 74.
3. " " 74 " " " " 100
4 " " 100 " " " " 200
5. " " 200.
6. Unsifted Cement.

Effect of Fineness Upon Tensile Strength.

Tests were made upon briquettes of the usual form composed of 1 part cement and 3 parts sand, using cement of the several degrees of fineness. Six briquettes of each grade were tested. The mortar had about the consistency of moist earth. The sand used was from a pit north of Urbana and was thoroughly washed and sifted to standard size, i.e. passing a No. 20 sieve and retained on a No. 30 sieve. The Böhmé hammer apparatus was used in moulding the briquettes as more uniform results could thus be obtained. As with this apparatus considerable time is taken to mould 6 briquettes care was taken that the cement did not take an initial set before

the moulding was completed. The briquettes were tested at 7, 30, and 60 days.

Tables I, II, and III present the details of the data and results, and Table IV shows a condensed summary of the same.

The tables uniformly show that the finer the cement the stronger the resulting sand mortar; and also that this difference decreases with the age of the briquettes, which agrees with the results found by Mr. Butler and shows that the coarse particles are more slowly disolved then the fine particles.

It will be noticed that the strength of the unsifted cement approximates that of the finest cement. This is as should be expected, since with both cements only 1/3 to 1/4 failed to pass the 200 sieve. Therefore the briquettes made with unsifted cement consisted of about 0.7 of one part of cement passing the 200 sieve, 0.3 of one part of coarse cement and 3 parts of sand. If instead of coarse cement an equal bulk of sand had been used the composition

of the mortar would have been 0.7 parts of cement and 3.3 parts sand or 1 part cement to 4.5 parts sand. However it is probable that if sand had thus been substituted, the strength of the mixture would have been less then that with the unsifted cement, since the coarse cement did have some hydraulic qualities, and also since the coarse grains of cement doubtless had rougher surfaces then the sand and therefore presents a better surface for the adhesion of the fine cement.

The economic value of fine cement can be shown crudely in another way. Roughly speaking the 0.3 of the cement not passing the No. 200 sieve was only 1/4 to 1/5 as strong as that passing the No. 200 sieve. Therefore the 0.3 not passing the No. 200 sieve is worth only 1/4 to 1/5 as much as the finer portions.

TABLE I

Effect of Fineness Upon Tensile Strength.

AGE: 7 DAYS.

Composition: Cement 1, Sand 3, Water 7.5%

ALPHA PORTLAND

Ref. No.	Degree of Fineness.	Pounds per Square Inch.						
		1.	2.	3.	4.	5.	6.	Average
1.	Passed 200.	331	317	326	316	346	318	326
2.	Retained on 200 Passed 100.	73	70	64	80	74	75	73
3.	Retained on 100 Passed 74.	15	30	34	30	25	29	27
4.	Retained on 74 Passed 50.	To weak to be taken out of moulds at end of 7 days.						
5.	Retained on 50 Passed 20.	" " " " " " " " " " " " " "						
6.	Unsifted.	266	287	282	270	280	294	280

ALSEN PORTLAND

Ref. No.	Degree of Fineness.	Pounds per Square Inch.						
		1.	2.	3.	4.	5.	6	Average.
1.	Passed 200.	241	215	232	230	289	219	238
2.	Retained on 200 Passed 100	132	118	133	112	110	116	120
3.	Retained on 100 Passed 74	69	68	78	78	68	70	72
4.	Retained on 74 Passed 50	To weak to be taken out of moulds at end of 7 days						
5.	Retained on 50 Passed 20	" " " " " " " " " " " " " "						
6.	Unsifted.	230	245	214	189	216	240	222

TABLE II

Effect of Fineness Upon Tensile Strength.

AGE: 30 DAYS.

Composition: Cement 1, Sand 3, Water 7.5%

ALPHA PORTLAND.

Ref. No.	Degree of Fineness.	Pounds per Square Inch.						
		1.	2.	3.	4.	5.	6.	Average
1.	Passed 200	345	338	291	318	342	337	328
2.	Retained on 200 Passed 100	174	175	182	150	178	150	168
3.	Retained on 100 Passed 74	96	95	82	99	91	104	94
4.	Retained on 74 Passed 50	To weak to be taken out of moulds at end of 7 days						
5.	Retained on 50 Passed 20	" " " " " " " " " " " " "						
6.	Unsifted.	344	352	342	296	303	320	326

ALSEN PORTLAND.

Ref. No.	Degree of Fineness.	Pounds per Square Inch						
		1.	2.	3.	4.	5.	6.	Average
1.	Passed 200	278	300	264	265	307	280	262
2.	Retained on 200 Passed 100	190	170	174	172	178	186	178
3.	Retained on 100 Passed 74	120	120	113	121	107	---	116
4.	Retained on 74 Passed 50	To weak to be taken out of moulds at end of 7 days.						
5.	Retained on 50 Passed 20	" " " " " " " " " " " " "						
6.	Unsifted.	268	216	209	200	194	214	217

TABLE III

EFFECT OF FINENESS UPON TENSILE STRENGTH.

AGE: 60 DAYS

Composition: Cement 1, Sand 3, Water 7.5 %

ALPHA PORTLAND

Ref. No.	Degree of Fineness.	Pounds per Square Inch.						
		1.	2.	3.	4.	5.	6.	Average
1.	Passed 200.	470	426	430	490	464	434	452
2.	Retained on 200 Passed 100.	213	230	228	190	216	228	218
3.	Retained on 100 Passed 74.	120	114	171	141	101	180	138
4.	Retained on 74 Passed 50.	To weak to be taken out of moulds at end of 7 days						
5.	Retained on 50 Passed 20.	" " " " " " " " " " " " "						
6	Unsifted.	378	415	444	390	416	450	416

ALSEN PORTLAND

Ref. No.	Degree of Fineness.	Pounds per Square Inch.						
		1.	2.	3.	4.	5.	6	Average
1.	Passed 200.	307	320	274	314	307	320	307
2.	Retained on 200 Passed 100.	206	230	212	226	190	174	206
3.	Retained on 100 Passed 74.	116	134	117	120	116	138	124
4.	Retained on 74 Passed 50	To weak to be taken out of moulds at end of 7 days						
5.	Retained on 50 Passed 20.	" " " " " " " " " " " " "						
6.	Unsifted.	252	252	304	248	261	281	266

TABLE IV

Effect of Fineness Upon Tensile Strength.

Summary of Tables I, II and III.

Ref. No	Degree of Fineness.	ALPHA PORTLAND			ALSEN PORTLAND		
		7 Days	30 Days	60 Days	7 Days	30 Days	60 Days.
1	Passed 200.	326	328	452	238	262	307
2.	Retained on 200 Passed 100.	73	168	218	120	178	206
3	Retained on 100 Passed 74.	27	94	138	72	116	124
4.	Retained on 74 Passed 50.	To weak to be taken from moulds	No observations made.		To weak to be taken from moulds.	No observations made.	
5.	Retained on 50 Passed 20.	"	"	"	"	"	"
6.	Unsifted.	280	326	416	222	217	266

Effect of Fineness Upon Activity

The activity of cement of different finenesses was tested with the Gilmore wires. The attempt was to make pats of the same plasticity. The results are shown in Table V.

The data in Table V show that the finer the cement, the more active it is. According to Le Chatelier the setting of cement is due to the formation of a supersaturated solution which gradually deposits crystals until a solid mass is formed. If this theory is correct, it is clear that the finer the cement the more readily it dissolves; and therefore the sooner the supersaturated solution forms and the quicker the crystals are deposited. Owing to the effect of fineness upon activity, specifications for slow setting cement must not require very fine grinding unless admixtures of gypsum or other artificial means of rendering slow setting are to be permitted.

An interesting feature developed by the experiment was that the cement retained on the No. 100 sieve, set at the edges and on the surface of the pat but in the interior it had no coherence at all. In forming the pat the surface was smoothed over with a trowel which probably gave a better arrangement of the particles on the surface, i.e., the particles were fitted together more closely. Then too water always rises to the top of a pat; and this water very likely carried crystals with it and deposited them at the surface thus cementing the surface particles more thoroughly then those in the interior. These facts, it is believed, account for the above peculiarities.

TABLE V

Effect of Fineness Upon Activity

Alpha Portland

Ref. No.	Degree of Fineness	Per Cent Water used.	Gilmore Test.		
			Interval from time of adding water to		Difference or Time required to set.
			Initial Set.	Final set.	
1	Passed 200	28	1 hr 45 min.	4 hr. 28 min.	2 hr. 43 min.
2	Retained on 200 Passed 100	30	1 hr. 37 min.	15 hr. 50 min.	14 hr 13 min.
3	Retained on 100 Passed 74	31	3 hr. 42 min.	19 hr. 48 min.	16 hr. 6 min.
4	Retained on 74 Passed 50	29	4 hr.	More than 72 hr.	More than 68 hr.
5	Retained on 50 Passed 20	30	19 hr 25 min.	"	More than 52 hr.
6	Unsifted.	22	1 hr. 45 min.	4 hr. 47 min.	3 hr. 2 min.

Alsen Portland

Ref No.	Degree of Fineness.	Per Cent Water used	Gilmore Test.		
			Interval from time of adding water to		Difference or Time required to set
			Initial set.	Final set.	
1.	Passed 200.	33	43 min.	3 hr. 29 min.	2 hr. 46 min.
2.	Retained on 200 Passed 100.	40	2 hr. 45 min.	10 hr. 30 min	7 hr. 45 min.
3.	Retained on 100 Passed 74.	41	2 hr. 33 min.	More than 72 hrs.	More than 69 hrs.
4.	Retained on 74 Passed 50.	40	4 hr. 40 min.	"	More than 67 hrs.
5.	Retained on 50 Passed 20.	40	11 hr. 19 min.	"	More than 51 hrs.
6.	Unsifted	28	23 min.	2 hr 15 min.	1 hr. 52 min.